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Enhancing Regional Climate Resilience of Indian Fisheries Through Wetland Restoration and Scientific Fish Farming

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ABSTRACT: *Development of climatic resilient strategies even at regional levels is of necessity to cope up with climatic change impacts. This paper highlights wetland restoration along with incorporation of scientific fish farming at village level as a significant climatic resilient strategy. Geospatial techniques have been considered as tool for degraded regionalwetland resource mapping and eco management plan development. A comprehensive approach by integrating qualitative as well as quantitative assessment of wetland is projected through this work. Scientific bodies are recognized to offer consultancy and monitoring throughout the project phases. Participatory programs with retaining the privileges of traditional local groups over the regional wetlands areenvisaged as project components. Scope of improved capture fisheries technique towards ensuring food and nutrition security, along with role of scientific bodies in assisting selection and implementation of proper aquaculture techniques are also mentioned. Utilization of equipments such as 'aquatic weed harvesters'instead of manual removal of aquatic weeds is proposed. Conversion of the harvested aquatic vegetation into climate resilient products such as biochar, biofuels and value added products are anticipated as sustainable options. The proposed concept model thus includes regional level wetland resource mapping and restoration, coupled with implementation of scientific fish farming as per the guidelines and consultation of scientific bodies.*

Keywords: *Aquaculture, climate resilience, remote sensing, wetland restoration.*

INTRODUCTION

Climate changes had created several impacts on various sectors and accordingly research programs across the nations are focusing on development of climate resilient strategies both at regional and global level. A 'No Regret' resilience strategy is more preferable [1,2], which should have multiple advantages beyond addressing a specific climate impact projection. Resilience in fisheries sector is of greater significance, since it plays a major role in food security as well as livelihood improvement. Extension and scaling up of aquaculture practices and techniquesto moreareas that are not presently utilized to optimum shall be a feasible option to meet the global fish supply demand. Wetlands host as important resources for fish farming as well as provides habitat for several speciesand hence the conservation is of high significance owing to its multiple ecological functions.

Wetlands also play significant role in regulating global climate change by carbon sequestration and release as well as stabilize the microclimate of the area. IPCC issues the 2013 wetland supplement[3]to 2006 IPCC guidelines[4], which include updated information and methodologies for reporting green house gas emission from wetlands. Accordingly, pressure to manage the wetland ecosystem shall mount up on each nation.However, strategies should focus not only on developing wetlands with reduced GHG emissions, but also should be comprehensive by enhancing the wetland ecosystem functions such as productivity, habitat, biodiversity, recreation, etc.Manuals are available on measurement of GHG emissions from various sub sectors of agriculture including aquaculture [5].

A spatial database of the wetlands of India above the size of 2.25ha with state wise wetland atlas was already created using RESOURCESAT-1 LISS III

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remote sensing data at 1 : 50,000 scale, through the National Wetland Inventory and Assessment (NWIA) project [6, 7]. The NWIA project reports extend of wetlands estimated as 15.26 mha and inland wetlands of the nation as 69.22% of the total wetland area, whereas the coastal wetland accounts to 27.13% and remaining 3.64% includes small wetlands that are less than 2.25ha [6]. In India 5,55,557 small wetlands were detected and mapped as point features [7].

Wetland restoration provides immense benefits in terms of climate change [8]. The response of wetlands to climate change shall not be uniform and depends upon location, type, biotic and abiotic components and several other processes [9]. Owing to the highly variant climatic zones of the nation, the regional impact of climatic parameters may also be diverse, which points out towards the need for regional level wetland impact projections.Thus region specific strategies for wetland restoration need to be developed. The potential of restored wetlands for aquaculture [10] is of scientific and ecological interest.

Aquaculture practices are advancing well in many wetlands across the globe. India being the second largest aquaculture production country, exhibits significant prospects in the sector. Conventional as well as diversified species culture practices marked significant growth areas of India's aquaculture scenario,leading to substantial socioeconomic benefits along with utilization of un-utilized or under-utilized land and water resources [11].

In the context of developing strategies for climate resilient agriculture, wetland restoration coupled with scientific fish farming is highlighted through this paper as a prospective concept to enhance climatic resilience even at regional levels.

RESILIENT STRATEGY

A concept model for wetland restoration coupled with scientific fish farming as shown in figure.1is presented through this paper as a promising 'No Regret' fisheries resilience strategy for the nation, with multiple advantages of GHG emission reduction, climate resilient product development, habitat creation for aquatic lives, biodiversity conservation, capture fisheries improvement, livelihood supplementation, etc.

Geospatial techniques could be considered as a tool to assess and project the possible climate related and other threats or stressors such as floods, storm water influx, agricultural runoffs, pollutant discharge, drainage pattern, catchment area status,etc on wetland ecosystems at village or panchayat level. Though such regional level qualitative assessment using geospatial techniques helps to identify and manage the vulnerable or degraded wetlands, continuous monitoring of the wetland ecosystem through quantitative analysis is also of utmost importance for long-term sustainability of the conservation efforts. In this context, we propose to incorporate scientific fish farming with the participation of local communities or stakeholders in the restored wetlands, so as to facilitate the development of regular monitoring system of the health and habitat suitability of the wetlands. Quantitative analysis of the wetlands including physicochemical analysis of water quality, toxicity analysis, etc is of necessity for scientific fish farming and thus the coupled model could result in comprehensive qualitative and

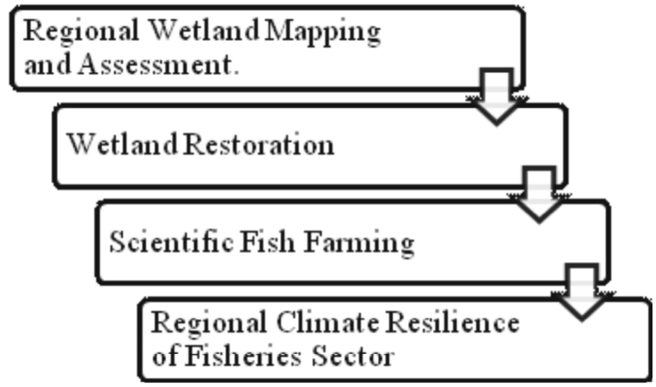

Figure 1: Representation of Regional Climate Resilient Strategy

Figure 2: Spread of water hyacinth in regional water bodies of Kochi, Kerala;
Photo: The Hindu, 27.10.2015.

Figure 3: Degraded wetland of Kannur district, Kerala.

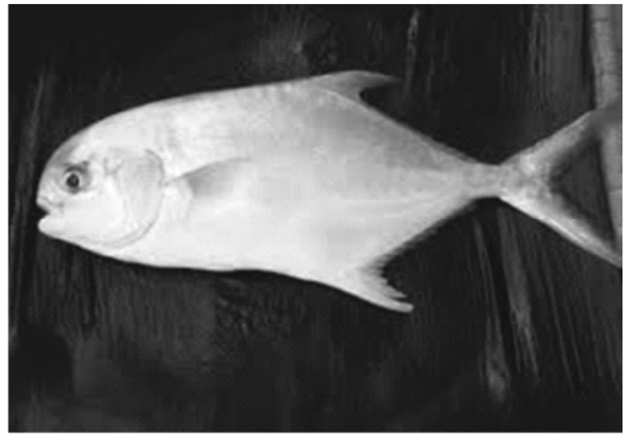

Figure 4: Silver pompano *Trachinotus blochii* [17]

quantitative assessment. The proposed model helps in the continuous eco health monitoring of the regional wetlands. Regional degraded wetland resource mapping could be attained by Geospatial techniques which shall favours further eco management plans.

The nature and ecological functions of each of the regional wetlands need to be scientifically investigated and accordingly 'Regional Wetland Restoration Guidelines' can be prepared for consideration throughout the project phases. Reports are available on the assessment of regional wetland [12] for restoration, by considering the geographical settings, catchment area, slope, drainage pattern, sedimentation, land use and water quality parameters [13, 14]. Figure 2, 3 represents degraded regional wetlands of Kerala state.

Though scientifically studied regional wetland 'Kottayam chira' of Kerala [13,14] was subjected to the restoration efforts through the 'Sahasra sarovaram' project of the state government, the aquatic weed removal and desiltation were not effectively attempted at the implementation phase. This highlights the necessity of incorporation and close monitoring by scientific body throughout the restoration stages, which could advocate the need to focus on the health and habitat of the ecosystem. In the Ramsar guidelines long-term stewardship was mentioned as one among the principles for wetland restoration. We envisage incorporation of scientific fishing project as a long term stewardship to monitor and conserve the regional wetland ecosystem as well as to enhance climatic resilience of fisheries sector. Feasibility and guidelines for development of suitable fish farming practices could be offered by the scientific bodies. Vulnerable or affected communities due to climate change can be given priority to get associated with multiple phases of fish farming projects so as to supplement their livelihoods. Case studies on participatory programs for the management and conservation could be considered along with resolving associated issues for the successful implementation of the project [15]. However care should be taken not to marginalize the privileges of individual or traditional group over the wetland dependency for livelihood. Successful scientific fish farming projects in restored wetlands could considerably favour towards the self reliance of wetland maintenance and development,by allocating a portion of the generated revenue from the project.

Improving capture fisheries at regional level shall be a significant step towards combating food scarcity. Since degraded wetlands are normally unfit for fish farming practices, the wetland restoration provides opportunity of new fishing areas and thereby provides scope for better capture fisheries. Exploration of coastal, fresh water and estuarine wetlands for fish farming reduces the over-exploitation pressures of oceanic fisheries resources. Climate resilient as well as stress tolerant fish species

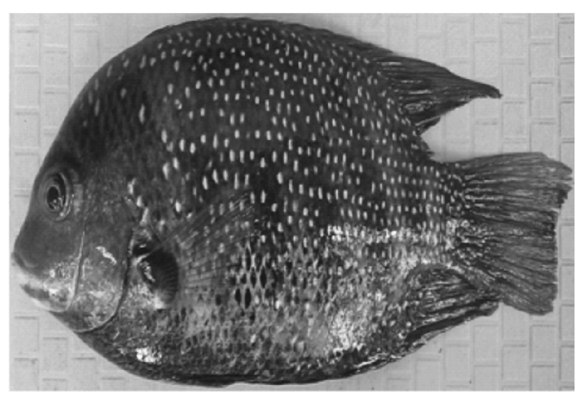

Figure 5: Pearl Spot*Etroplus suratensis;*
Photo by Saralstalin - Licensed under CC-BY SA 3.0

Figure 6: Cage culture of finfish in Pokkali Fields of Kerala by KVK-CMFRI, Kochi

Figure 7: Sea weed culture integrated to cage farming by CMRFI, Mandapam Research Centre

[16] such as silver pompano Trachinotus blochii, Pearl Spot Etroplus suratensis, etc shown in figure 4, 5 can be added as per the health and habitat status of the wetland. However native fish species shall be favoured and conserved in the fish farms so as to enhance the biodiversity profile.

The concerns over aquaculture impacts on wetland habitat [18] could be addressed at the planning stage and accordingly sustainable aquaculture with long term benefits can be implemented.A nation like India with huge population cannot afford a back foot on aquaculture practices and hence shouldprogressively focus on extending sustainable aquaculture practices, so as to meet the growing food and nutrition demands of millions. Regional fisheries resilience with wise use of wetlands shall ensure food and nutrition security at village levels, whereas the surplus can be channelized towards global supply chain.

Based on the wetland characteristics, suitable eco friendly aquaculture techniques can be adopted for small scale as well as large scale farming practices. Several reports and guidelines are available [19, 20, 21, 22] which provides valuable insights for planning the aquaculture practices. Integrated polyculture farming practices are one among the promising option and in shallow wetlands of India co-farming of paddy with fish are in practice [23]. Cage farming being widely practiced in lakes, ponds and temporary water bodies poses as a feasible option. Central Marine Fisheries Research Institute (CMFRI) had successfully demonstrated under the NICRA project [24] that cage farming of finfish in pokkali fields of Ernakulam district, Kerala as shown in figure. 6 could improve the economies of pokkali rice cultivation [25].

Integrated Multi Trophic Aquaculture (IMTA) is another emerging and potential area that could be considered with significant ecological advantages also. Mandapam Research centre of CMFRI had attempted IMTA as shown in figure 7. Competent fisheries related scientific bodies or agencies could provide necessary guidelines and monitoring of suitable aquaculture practices. Scientific guidelines could be offered for multiple stages of aquaculture such as choice of species, selection of farming practice, seed production, spawning enhancement, stocking, hatchery development, aquatic animal health, effluent treatment, etc. Scientific consultancy along with capacity building has to be made as an integral part throughout the project phases, so as to enhance the overall sustainability.

The spread of aquatic weeds poses serious damages leading to degradation of several regional wetlands. Extend and type of aquatic vegetation can be considered as an indicator of the aquatic pollution level. In India, aquatic vegetation accounts for around 9 and 14% of total wetland area in post monsoon (1.32 mha) and pre monsoon (2.06 mha) respectively [6]. It has to be pointed out that the regional impact of aquatic vegetation over wetland shall be much higher. The uncontrolled excessive

Figure 8: Aquatic Weed Harvester;
Photo: www.tradeindia.com

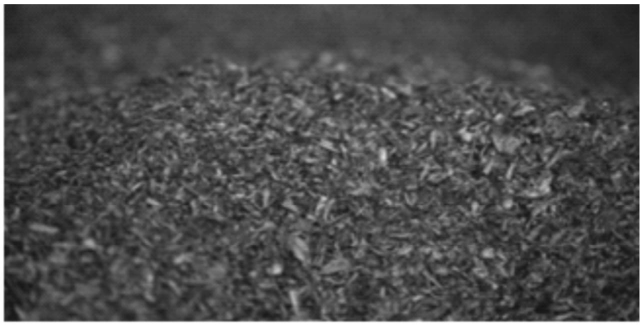

Figure 9: Biochar from biomass
Photo: Ryan Kendrick Smith/Flickr (CC BY-NC-ND), Oregon Department of Forestry

growth and spread of aquatic weedssuch as water hyacinth (*Eichornia crassipes*)reduces the dissolved oxygen content, favours the development of anaerobic conditions, makes the habitat unfit for the aquatic lives and thereby eventually leads to the degradation of regional wetland ecosystem. The spread of aquatic vegetation also causes hindrances to the fishing practices and thus induces negative impacts to the livelihoods of dependent fishermen. Removal and control of aquatic weeds is a challenging necessity towards restoration efforts. Application of herbicides is not sustainable and alternative means needs to be preferred. Though manual removal is tedious and futile, the utilization of equipments such as 'aquatic weed harvesters' shown in figure. 8 are promising and can be considered. The equipments are effective in removing floating as well as submerged aquatic vegetation to the shore.

CLIMATE RESILIENT PRODUCTS FROM AQUATIC WEEDS

The sustainable disposal of harvested aquatic weeds can be attained by its conversion into climate resilient products such as biochars, biofuels and other value added products, which provides gain on enhanced carbon sequestration. Aquatic vegetation biomass can be pyrolysed into biochar shown in figure 9, which is considered as a carbon sequestration means.

The C content of the aquatic biomass could be converted into more stable biochar, which can be locked beneath the soil for several years through agricultural applications. Reports are available on biochar production from aquatic weed *Eichornia crassipes* (water hyacinth)[26]and other feed stocks [27, 28]. Besides, reports are available on the bioconversion of aquatic biomass into bioethanol [29, 30]. Cellulosic content of the aquatic biomass can be converted to glucose followed by fermentation to bioethanol. Bioethanol production from aquatic vegetation is also a promising option towards exploration of alternative energy source to reduce the burden of fossil fuel combustion along with additional benefits of pollution abatement coupled with eco-friendly weed management. Conversion of aquatic weeds into climate resilient products [31] and other value added products as shown in figure. 10 also offers the scope of revenue generation.

Figure 10: Bag made using water hyacinth
Photo: http://www.natural-mystique.com

In a restored wetland with aquatic weed removal, the incorporation of certain fish species shall provide opportunities for upcoming aquatic weed management.

CONCLUSION

Wetland restoration coupled with scientific fish farming is presented as a promising strategy towards enhancing regional 'Climate Resilient Agriculture'. Owing to the vast diversity of the nation, India can make significant sustainable aquaculture progress in restored fresh water, estuarine as well as coastal wetlands. Besides regional ecosystem improvement, the concept model foresees increased fish production leading to enhancement in food and nutrition security. Scientific bodies could provide necessary guidelines for regional wetland restoration as well as selecting suitable aquaculture techniques. Climate resilient products from aquatic weeds shall provide multiple benefits towards wetland restoration, sustainable energy generation as well as carbon sequestration. The model could be focused to implement at village or panchayat level, which shall open new horizon towards climate resilience. The multi stage concept model shall be a significant step towards climate resilient cities or villages.

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